Energy Concerns in Agro Based Monitoring using Wireless Sensor Networks

[1]R. Selva Rama Devi, [2]V.R. Sarma Dhulipala

[1] Dept. of Pervasive Computing Technologies, Anna University of Technology, Tiruchirappalli, Tamil Nadu, India

[2]Dept. of Center for Convergence of Technologies, Anna University of Technology, Tiruchirappalli, Tamil Nadu, India

Abstract

Energy is a mandatory limiting factor for wireless sensor network (WSN) during the design process. Energy is accosted in networking, control and monitoring applications such as habitat monitoring, health care applications, home automation and animal behavior monitoring. Animals' neck movement is monitored to generate sufficient energy. Movement of the neck is based on existing literature and respective stochastic models. By applying Faraday's law, voltage is produced from the animal neck movement is converted to power, which serves as energy scavenging for a wireless sensor node. This study proposes that the amount of energy generated by the vertical neck–head movement of sheep during grazing can be converted to useful electrical power adequate to provide power for operation of WSN.

Keywords

Wireless Sensor Network (WSN), Faradays law, Random signal, Matlab

1. Introduction

Random signals are random variables developed with respect to time, distance and some other parameters. Random signal's deals with unpredictable voltages. There is a need to provide consistent power for the system for maximum efficiency. A consistent energy supply is imperative to ensure the optimum performance of wireless sensor networks (WSN). This is particularly challenging in networking, control and monitoring applications such as habitat monitoring, healthcare applications, home automation, transportation systems and animal behavior monitoring. Animal monitoring is important to understand animal behavior, to detect individual animals for their health problem. Monitoring animals in an extended area using the wireless sensor network is emerging trends [2]. For instance, the positions of animals in the field were tracked and monitor [11-15]. Using an accelerometer the pitch angle of the neck is noted for the animal behavior [1]. During animal monitoring energy consumption by sensor node is more and to avoid this energy generation is made by the movement of animals by attaching a sensor board on the halter [1]. Initially animal monitoring was done in a number of ways using sensor system [7-9]. Zebra Net [7] animal tracking collar; GPS-based tracking such as Tellus collars is available in past years. Routing protocols focused on energy efficiency and many algorithms are designed to reduce energy consumption [5- 6]. The main drawback of such an energy generation method is the inefficiency when deployed in northern latitudes where solar radiation energy density is very low, and dust and dirt accumulation on the solar panels negatively affect the efficiency of the system [16, 18].

The main objective of this paper was to investigate a potential source for energy generation for a MANET-based animal behavior monitoring system. To carry out this investigation, each animal in a small flock was equipped with a wireless module capable of measuring and monitoring head/neck movements. The behavior of the flock was recorded and observed prior to the deployment of the wireless modules and no change in the behavioral pattern due to the deployment of wireless modules was observed. The amount of energy generated by the neck/head movements during the downward movements of all 10 ewes and the ram in mW, and the amount of energy generated by the ram was larger than that of the ewes that was due to the rams' higher level of activity from existing literature [3].

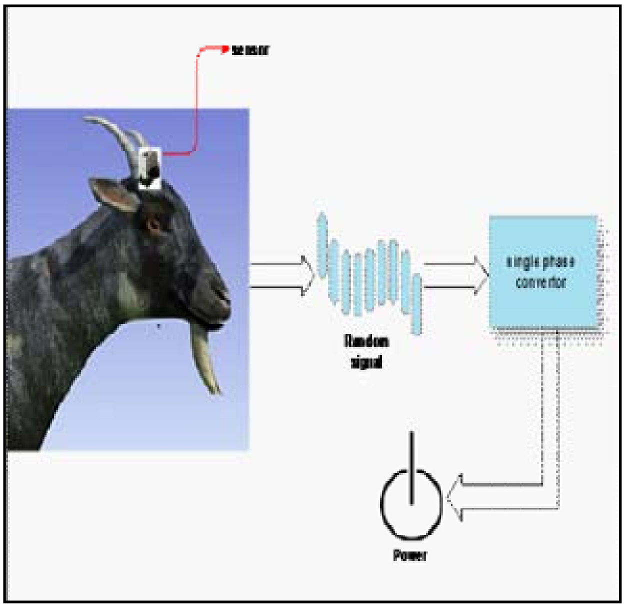

Fig. 1: Sensor attached to animal halter for power generation

Fig 1, shows that the sensor attached to the animal to measure the downward and upward movement to generate the random signal it is converted to voltage then by using single phase operation it is converted to power. The amount of voltage generated by head movements of an animal is calculated and presented in Section II. Power generation is described in Section III. Results of this study together with the discussion are presented in Section IV. Conclusions of this paper are described in Section V.

II. Mathematical description

Upward and Downward movement of the neck is taken to generate emf. Using random signal, voltage can easily be produced and can be converted to power. While monitoring the animals energy consumption occurs and to charge that sensor, this concept is used. Any change in the magnetic environment of a coil of wire will cause a voltage to be in the coil. The change could be produced by changing the magnetic-field strength, moving a magnet toward or away from the coil, moving the coil into or out of the magnetic-field, rotating the coil relative to the magnet, etc.

$$e = \frac{d\phi}{dt} \quad (1)$$

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Applying equation (1) and taking upward and downward movement of the head movement the equation obtained is,

$$e = \phi \frac{N}{L} \cdot \frac{dl}{dt} \qquad (2)$$

where,

ϕ design parameter
N number of turns
L length
l random
t time

Fig. 2, represents the algorithm to generate power. Random signal from existing literature is taken and by applying Faraday's law voltage is produced. Voltage signal is rectified average voltage is obtained by Eqs. (3) and power is generated using general equation. A critical constraint on the sensor's network is that sensor nodes employ batteries. A second constraint is that sensors will be deployed unattended and in large numbers, so that it will be difficult to change or recharge batteries in the sensors. Therefore, all systems, processes and communication protocol for sensors, and sensor networks must minimize power consumption.

III. Power generation

Single phase uncontrolled rectifiers are mostly used in a number of powers electronic based converters. They are used to provide an intermediate unregulated dc voltage source which is further processed to obtain a regulated dc or ac output. It contains some disadvantages. i.e.(this circuit only flows in one direction from ac to dc only). This leads to single phase fully controlled converters. Single phase uncontrolled rectifiers contains diodes, and it is replaced by thyristors in single phase fully controlled.

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X        displacement
emf →    electromotive force
V        voltage
I        current
P        power
BEGIN PROCESS
Create random signal
Plot random signal
Begin
For 1 to 3600
Calculate X.
X varies with points
Calculate emf.
IF V less than zero
Rectify negative value and calculate I
Power signal is generated from V,I
End
Calculate average V,I
Average P is measured from avg (V,I)
Plot V,I,P  with respect to time.
END PROCESS
```

Fig. 2: Algorithm to generate power

By using animal neck movement in the existing literature random signal generated with respect to displacement, and it is converted to voltage by applying Faraday's law. In the algorithm, first random signal is considered with respect to displacement and time. Displacement is calculated using existing literature data, and it is converted to voltage signal using Faraday's law. In this approach Single phase rectifier is used for the voltage signal rectification and pure dc signal is obtained. Fig. 3, gives the displacement graph. Graph was generated in Matlab simulation, data from existing literature.

IV. Result and analysis

Average voltage and current is obtained by using the following equations,

Voltage =2×max (v)/π (3)

Current =2×max (i)/π (4)

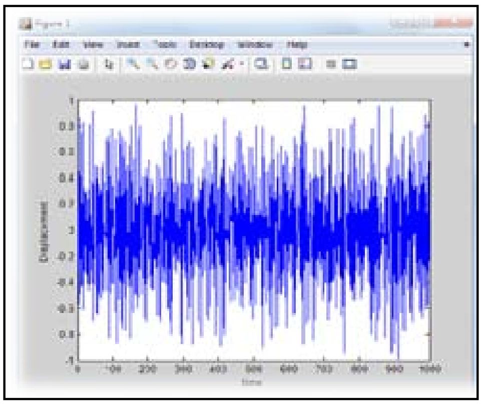

Fig. 3: Displacement with respect to time

Taking the number of turns of each coil (N=100) and the length of the movement (L=0.02m) into account, the amount of generated voltage during upward and downward movements during grazing can be calculated using Eqs. (1) and (2). Random signal contains noises in order to reduce it, Rectifier is used to obtain the pure voltage. Average voltage and current produced is calculated using Eqs. (3) and (4). It should be filtered and applied to nodes for applications. From the algorithm, voltage obtained is 3.1461v and current= 0.0315A, power is calculated with respect to seconds. In proposed work, the average power obtained is 90mW using Matlab simulation.

A wireless node with the specifications consumes approximately 117.8mW energy (T E) to transmit a data packet [17]. Comparing the amount of energy consumed by a wireless module with the specifications with the amount of energy generated by the head movements demonstrates that there is a possibility to benefit from animal head movements as a potential source of energy for the MANET-based animal behavior monitoring system.

V. Conclusion

While monitoring animals the random signals generated can be converted to power and applied to the nodes to reduce energy consumption. Minimum power generated will be useful to charge the nodes and monitor animals. The amount of energy generated by grazing animal head movement is converted to electrical power can provide adequate power to wireless sensor nodes. The Power generated was approximately 90mw in this approach.

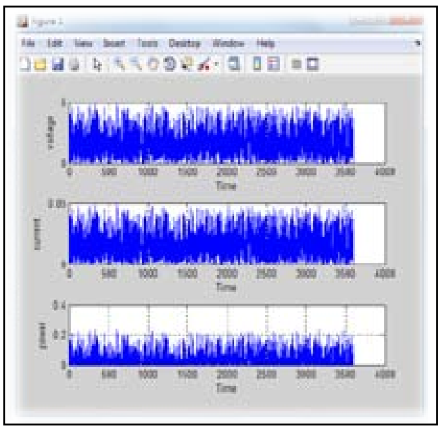

Fig. 4: Power generation

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